Arches and Circles

Calculation Formulae

Compiled by

Russell Engineering Co.

Boston ST. LOUIS New York

Arches and Circles

Fire brick arches are usually built of standard arch, wedge or key brick, or a combination of these and straight brick. All these standard brick are carried in stock by the Russell Engineering Co.

To Determine the Number and Kind of Brick Required to Turn an Arch: See Russell Engineering Co. Bulletin, "Standard 9-Inch Brick Shapes, Tables and Illustration." Tables published in Refractory Company pamphlets will also be found useful. These tables give the number of each kind of brick required to form one complete circle.

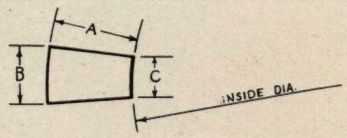
The proportion between the different kinds of brick for any given inside diameter or radius will be the same for any arc of the circle as for the entire circle.

To Find the Number of Brick Required to Form an Arch: Divide the number of each kind shown in table for the given inside diameter (twice the inside radius of the arch) by a figure obtained either by dividing the circumference of the inside circle by the length of the inside arc or by dividing 360° by the angle included between radial lines to the ends of the arch.

The length of the arc may be measured on the form or it may be secured by figuring from the radius and span.

When the span of the arch is the same as the radius, the number of each kind shown in the table should be divided by six.

To Find the Inside Diameter of the Circle Turned from the Dimensions of the Brick: Twice the length of the brick, representing the thickness of the wall, multiplied by the size of the brick at the small end and divided by the difference between the large and small ends will give the inside diameter of the circle.



$$\frac{2\ A \times C}{(B - C)} = \text{Inside Diameter}$$

Example: What circle will a wedge brick 3″ at large end, 2½″ at small end and 9″ long turn?

$$2 \times 9'' \times 2\tfrac{1}{2}'' = 45''$$

$$45'' \div (3'' - 2\tfrac{1}{2}'') = 45'' \div \tfrac{1}{2}'' = 90'' \text{ inside diameter.}$$

To Find the Number of Brick Required to Turn the Circle: Divide the inside circumference by the thickness of wedge at the small end.

To Find the Circumference of a Circle: Multiply the diameter by 3.1416; or for approximate purposes by $3\frac{1}{7}$.

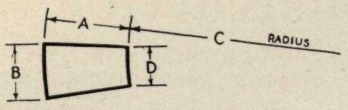
To Figure the Number of Straight Brick Required for a Complete Circle to Increase the Inside Diameter of Circle Turned by Any Given Arch or Wedge Brick or Tile: Multiply the increase in diameter by 3.14 and divide by the thickness of the straight brick.

Example: Wedge brick 3″ at large end, 2½″ at small end and 9″ long are to be used to turn a circle 9′-0″ inside diameter, how many standard brick 2½″ thick will have to be used with the wedge brick?

Wedge brick alone will turn a circle 90″ inside diameter (see previous example.) Required circle 9′-0″ = 108″ diameter. 108″ - 90″ = 18″ increase in diameter.

$$18'' \times 3.1416 = 56.5;\ 56.5 \div 2\tfrac{1}{2}'' = 22.6\text{—say 23 brick required.}$$

To Find Length of Inner Arc or Chord When Outer Arc or Chord is Known: Multiply length of outer arc or chord by inside radius and divide by inside radius plus width of tile.

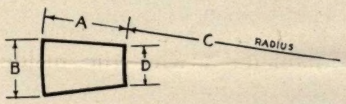


$$D = \frac{B \times C}{A + C}$$

Example: Outside arc = 9″; width of tile = 4½″; inside radius = 36″. To find inside arc:

9″ × 36″ = 324; 4½″ + 36″ = 40.5; 324 ÷ 40.5 = 8″ length of inside arc.

To Find Length of Outer Arc or Chord When Inner Arc or Chord is Known: Multiply inside radius plus width of tile by inside arc or chord and divide by inside radius of tile.

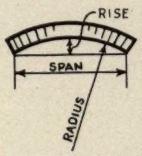


$$B = \frac{(A + C) \times D}{C}$$

Example: Inside Arc = 8″; width of tile = 4½″; inside radius = 36″. To find outside arc:

4½″ + 36″ = 40.5; 40.5″ × 8″ = 324; 324 ÷ 36″ = 9″ length of outer arc.

To Find the Radius of an Arch, When the Span and Rise are Given: Square the span or chord, divide by 8 times the rise and add ½ the rise:



$$\frac{\text{Span}^2}{8 \times \text{Rise}} + \frac{\text{Rise}}{2} = \text{Radius}$$

Example: Span of arch = 48″; rise = 9¼″. To find radius: 48² = 2304; 8 × 9.25 = 74; 2304 ÷ 74 = 31.13″; 9.25 ÷ 2 = 4.63″; 31.13 + 4.63 = 35.76″ Radius—say 36″ Radius.

To Find Length of Arc When Radius and Span are Known: Divide half the span by the radius.

From a table of natural sines determine the angle corresponding to this quotient, multiply the circumference by the angle found, and divide by 180. The result will be the length of the arc.

When the span is the same as the radius the length of the arc is one-sixth of the circumference.

Example: Span of arc = 4′-0″; Radius = 3′-0″. To find length of arc:
Half of span = 4 ÷ 2 = 2′-0″; Rad. = 3′-0″
2′-0″ ÷ 3′-0″ = 0.6667 = Sine

From table of natural sines determine the angle corresponding to sine .6667 = 41° – 10′ = 41 10/60 = 41 1/6°.

Rad. = 3′ — 0″ = 36″; dia. = 2 × 36″ = 72″
Circumference = 72″ × 3.1416 = 226.19″
226.19 × 41⅙ = 9311.5; 9311.5 ÷ 180 = 51.73″ — say 51¾″ length of arc.

To Find the Rise of an Arch, When the Span and Radius are Given: Square the radius; also square ½ the span; subtract the latter from the former, take the square root of the remainder, and subtract the result from the radius.

$$\text{Radius} - \sqrt{\text{Radius}^2 - \tfrac{1}{2}\ \text{Span}^2} = \text{Rise}$$

Example: Span of arch = 48″; radius = 36″. To find the rise: 36² = 1296; 48 ÷ 2 = 24; 24² = 576; 1296 — 576 = 720; $\sqrt{720}$ = 26.8; 36″ — 26.8″ = 9.2″ Rise—Say 9¼″ Rise.

To Estimate the Weight of Fire Clay Tile: Multiply the volume of the tile in cubic inches by .075. This equals the weight in pounds.

Notes and Formula on Fire Brick Construction

For every service there is one grade of fire brick which will give best and most economical results. This is not always the most refractory or the most expensive brick. It is the brick that best meets the firing conditions under which it is used. Be sure to get the right brick for each job.

Fire brick, tile and clay should be kept in a dry place.

The mortar or refractory cement used should be at least as refractory as the fire brick. If clay, or a mixture of clay and ground brick, is used, both should be the same grade as the brick.

Remember that unburned ground fire clay has no bonding qualities. All joints therefore should be as thin as possible.

When laying up fire brick they should preferably be dipped in mortar of the consistency of thick cream, but may be buttered, providing all joints are kept thin and full.

Fire clay mortar works best after standing 24 to 48 hours. Therefore, whenever possible, the water and clay should be mixed a day or two before being used.

For laying fire brick, 500 to 600 lbs. of clay will be required per 1000 brick. For small jobs, extra clay should be ordered to cover unavoidable waste.

In estimating number of fire brick required, figure 6½ brick per sq. ft. of wall for each 4½" in thickness. This will be ample, except on jobs requiring less than 1000 brick, when 7 brick per sq. ft. should be used in calculating. For irregular or massive work, figure 17 brick per cu. ft.

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RUSSELL ENGINEERING COMPANY

Russell Tunnel Kilns

New York ST. LOUIS Boston

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